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Response to Office Action

Claims objections

As described above, claims 7 and 13 have been amended in response to the objections raised by the examiner.

Claim Rejections under 35 USC §112.

As described above, the claim 13 has been narrowed to exclude control systems other than the described electromechanical motor control described at length in the specification. (Although "illumination" and "temperature" could be controlled with a servo-loop modified with an oversampled DAC as disclosed, there was no explicit or implied mention of such systems in the specification.)

Claim Rejections under 35 USC §103.

The claims 7-12 and 13-17 were rejected under 35 U.S.C. 103 as being unpatentable over Kobayashi et al. (6,153,997) in view of Bibyk (6,202,198).

As was discussed in the telephone conversation on 22 December 2005 between the examiner and the inventors, the objection relates to whether the inclusion of a technique well-known in the field of signal processing codecs (Bibyk) into systems very clearly similar to the present inventions servo control loop (Kobayashi) would be obvious to one skilled in the art.

The following are the reasons why the applicants contend that the invention is not obvious:

1. **Combination of art from different fields:** Codecs versus Servo Loops are nonanalogous art.

As discussed, in the field of codecs, analog to digital and digital to analog conversions have system requirements quite different than those of servo systems. These lead to designers in one field achieving solutions differently, and even defining the nature of common problems in differing terms that are inimical to using common approaches:

   A. Open loop versus closed loop: The field of codecs is limited to open-loop systems. These systems have defined inputs and outputs that both may be in

the physical world as shown in fig. 1 of Bibyk, as in the example of a telephone system. But the system lacks important features that would allow it to be used as a closed-loop system as is the nature of the art of electromechanical servo systems. Closed loop systems are primarily concerned with controlling a particular output and the design of which centers around the competing issues of maintaining tight control and maintaining stability of the resulting negative feedback loop.

B. Differing concepts of accuracy: In servo systems, the primary descriptions of DAC performance are absolute DC accuracy and settling time. In codecs, signal integrity (noise, distortion, etc) is important but latency (delay) and absolute DC accuracy are not typically critical. Although the requirements are not mutually exclusive, the way the problem of accuracy is defined leads directly to the nature of the conventional solutions in either art, and tends to preclude solutions that are conceptually modeled along different lines.

C. Differing levels of abstraction: The complex mixed-signal nature of a codec leads to acceptance of solutions that are at levels of abstraction far removed from simple analog-digital-analog block diagram representations. Conversion of analog signals to a wide variety of digital formats, and trans-coding between those formats, suggests to those in this field that conversion between multiple representations is normal and the abstraction of digital to bitstream to analog is a minor issue of signal complexity. In servo systems, the digital representation of signals is hidden by the "black box" of the microcontroller, which occasionally outputs a digital value to a converter, and that digital value is considered to be representative of an absolute analog value. Adding a further level of abstraction, such as converting the digital value commanded by the microcontroller to an oversampled bitstream representation, is not a leap that would be seen as obvious to those skilled in the art of designing motor servo systems.

2. Unsuggested Combination

Neither cited reference suggests that such a combination would be desirable. Bibyk, though describing the driving of motors and loudspeakers at the output of the codec

system, does not suggest any means nor any desirability in creating a closed loop system. Further, his system as described, lacking any means for compensating (stabilizing) such a loop, is inappropriate for such a task. Similarly, Kobayashi never provides any motivation for replacing the DAC in the described servo system, and certainly no motivation for moving from a DAC with a defined analog output level to a converter with a time-varying bitstream output.

3. Unexpected Results

As was discussed in our telephone conversation, the use of the oversampled DAC has unexpected results. This is particularly evident when the idea is disclosed to those skilled in the art of motor control systems. Although this replaces a high resolution DAC (often the most critical piece of analog design in the system) with a digital circuit without a discrete analog output value, the system nevertheless has been shown to have the following significant advantages:

A. The oversampled modulator is significantly smaller and cheaper than the conventional DAC,

B. Increasing the resolution of the modulator has a small impact on size and cost, whereas it has a large impact on the size and cost of the conventional DAC.

C. The DAC becomes easier to test as it is no longer necessary to measure absolute DAC accuracy, particularly DNL (dynamic non-linearity).

D. Without increasing the system calibration complexity, the new system improves on both the dynamic range and the DC accuracy of the system.

4. Assumed Unworkability, Unappreciated Advantages

Those skilled in the art of motor control servo systems are familiar with DAC schemes using pulsed techniques, as pulse width modulated (PWM) schemes were at one time common, as many microcontrollers implemented PWM as a simple means of generating analog values in a digital system. These schemes were rejected as accuracies increased, as PWM schemes above 8 to 10 bits become difficult to implement: the clock rate of the underlying timing generator needing to be many orders of magnitude greater than the system bandwidth. As a result, bitstream

converters are immediately associated with a wide range of problems generally assumed to be inherited from these earlier and far inferior systems. Further, as the old PWM schemes were implemented at lower frequencies than would be typical, a wide range of noise and filtering problems were associated with their use.

5. **Lack of Implementation**

Commercial systems using oversampled DACs in signal processing applications are well known (e.g. the ubiquitous "one bit DAC" of consumer audio gear) and date back at least to the introduction of Philip's co-introduction of the audio CD in 1982. These applications use low-cost and yet very high performance DACs. Motor control servo systems using DACs are also in need of cost-effective, high performance converters, yet to date neither the patent literature nor searches of commercial and academic sources have yielded any indication that this combination has previously been proposed. This leads to the conclusion that this combination is not obvious to those skilled in the art.

The examiner has also suggested a combination of Bibik and Contreras (6,154,017) to argue the obviousness of the software implementation. The applicants contend that being Bibik not applicable for the above mentioned reasons, the software implementation of oversampling DACs for motor control applications is not obvious to those skilled in the art.

Therefore the applicants submit that Claims 7 through 18 are not obvious, and are therefore allowable over the cited references and respectfully solicit reconsideration and allowance.